

HAVE URBAN AND AGRICULTURAL LAND USE CHANGES AFFECTED CALIFORNIA'S CLIMATE?

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Land Use and Climate

- Numerous local and regional field studies, as well as global climate modeling studies, have indicated that changes in land surface characteristics (land cover) can have large impacts upon climate, especially at regional scales
- These climate impacts primarily take the form of changes in temperature or moisture

Land Use and Climate

- The land surface currently covered by pastures, agriculture and urban environments cover ~41% of the Earth's ice-free land surface
- The total farmland in the western US is ~18% of the US total farmland
- Irrigation has been used to offset/overcome rainfall deficiencies on > 18 million acres in the western US

The California Energy Commission Regional Climate Model Intercomparison Project

- The primary goal of this exploratory study is to investigate the role that past land use changes may have had on California's climate, focusing upon the impacts of irrigation and urbanization
- This study relies upon regional climate models (RCMs) with different characteristics and levels of development

The Intercomparison Project Research Plan

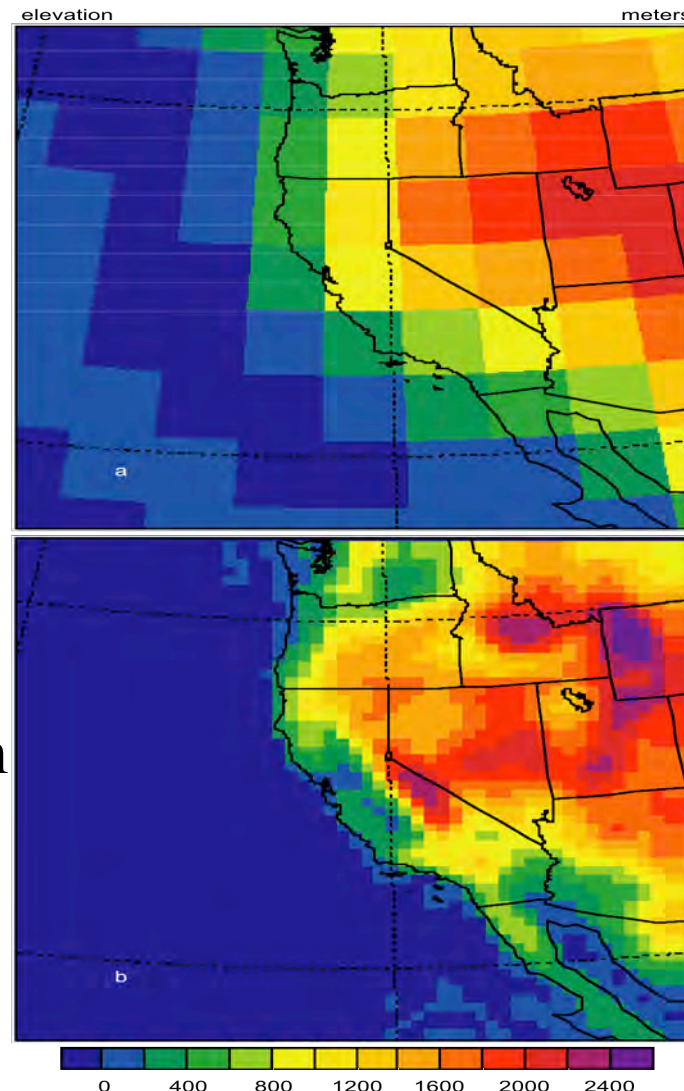
- The initial phase of this project is a comparison between RCM experiments using a modern land surface (circa 1992) and a pre-settlement, potential, natural vegetation land surface (pre-1850).
- A suite of RCMs used land cover source data for these time intervals, and all used the same atmospheric driving data at the lateral boundaries of a common model domain

WHY USE A REGIONAL CLIMATE MODEL?

- Regional climate models allow greater detail than is possible in global models
- RCM physical processes are described at more appropriate spatial scales than in GCMs
- RCMs being used increasingly for climate change and climate impacts studies

GCM
(~300
km
gridpt
side)

RCM
(~40 km
gridpt
side)



Why use multiple RCMs?

- As in the case of IPCC and global climate models, the use of multiple models to investigate a problem helps to overcome biases in any single model
- The use of multiple models should help to highlight the truly robust climate responses to a given forcing factor

The Regional Climate Models

- RegCM3-BATS (UCSC)
- MM5-CLM3 (LBNL)
- Regional Spectral Model (RSM) - NOAA (Scripps)
- The models vary in their description and parameterization of some climate processes. Of paramount importance to this study is the differential treatment of irrigated cropland and urban land cover types

Model Treatment of Irrigated Cropland

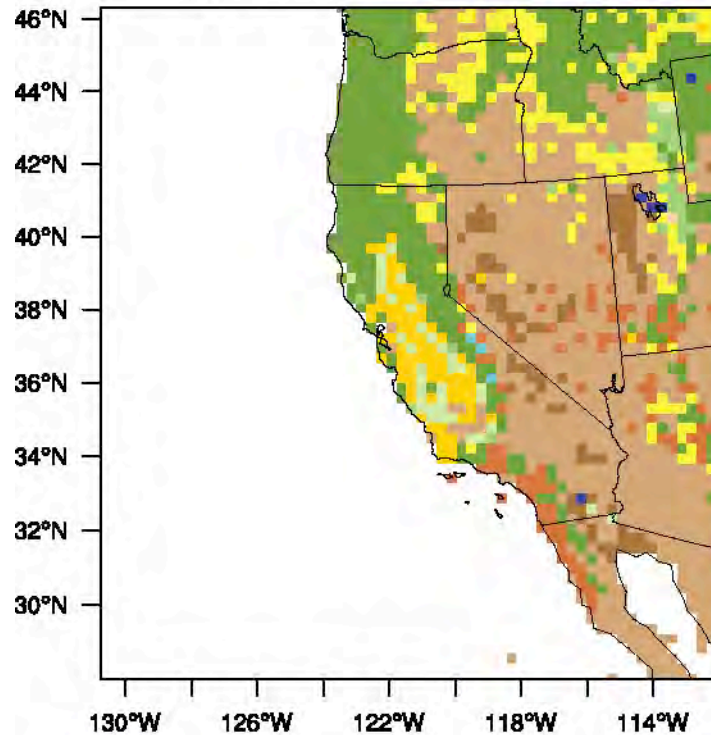
- RegCM3 forces irrigated cropland to be at field capacity (maximum water held by soil column against gravity)
- MM5-CLM3 does not specifically include irrigated cropland
- RSM forces irrigated cropland soil to be saturated

Land Cover Distributions

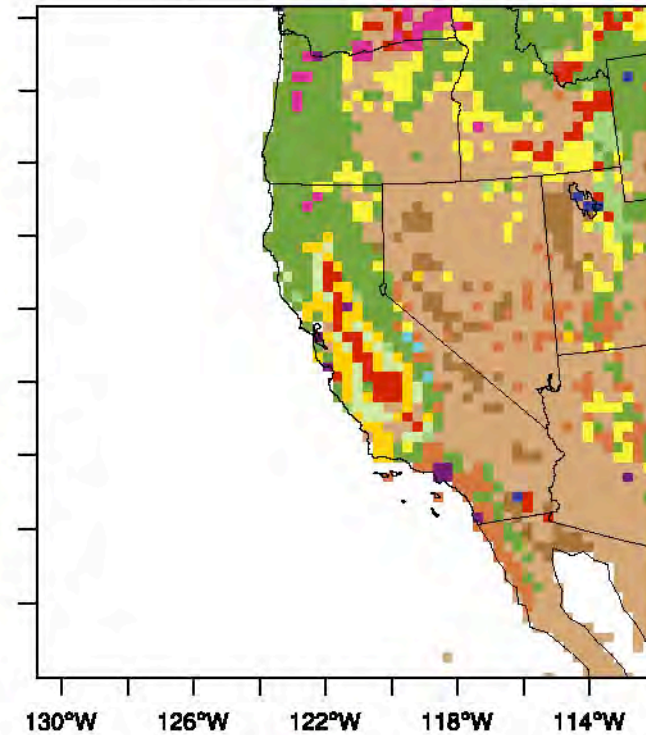
- Each model was used to examine modern and pre-settlement climate as forced by land cover
- The different models began with the same land cover depictions but were modified to fit land cover categories in each land surface submodel

RegCM3 LAND COVER

RegCM3 Presettlement Vegetation

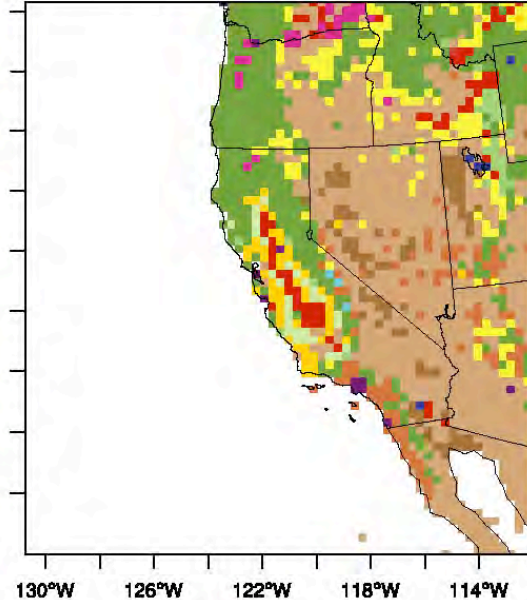


RegCM3 Modern Vegetation

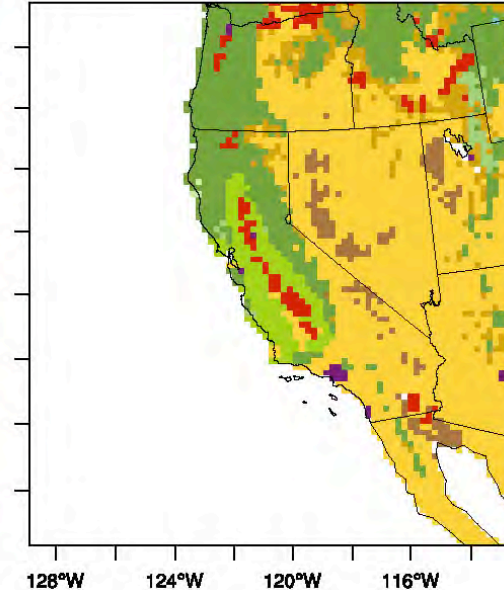


MODERN LAND COVER

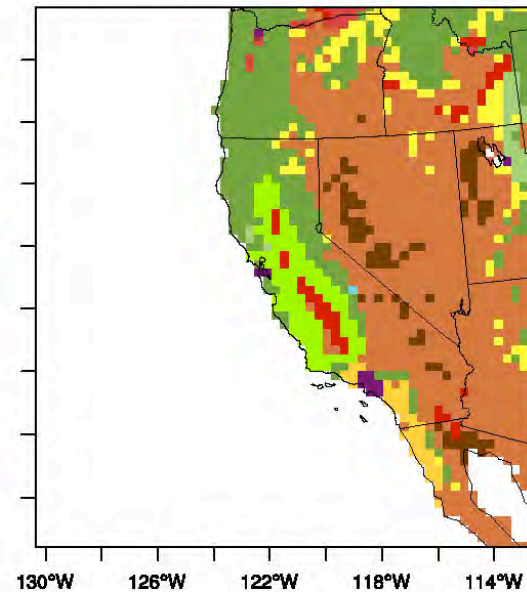
RegCM3 Modern Vegetation



RSM Modern Vegetation



MM5-CLM3 Modern Vegetation



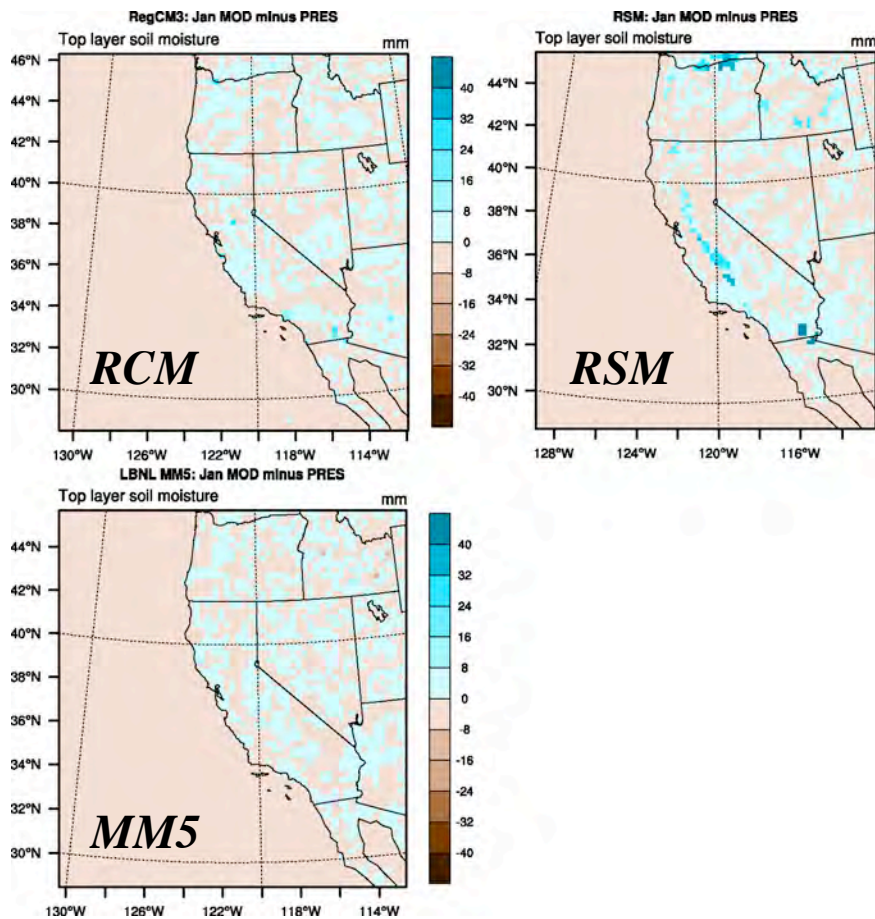
- All models show similar extent of urban and agricultural landcover
- RSM has greater areas of grasslands in the intermontane west
- MM5 has more shrubland
- RegCM has more desert

Initial Results

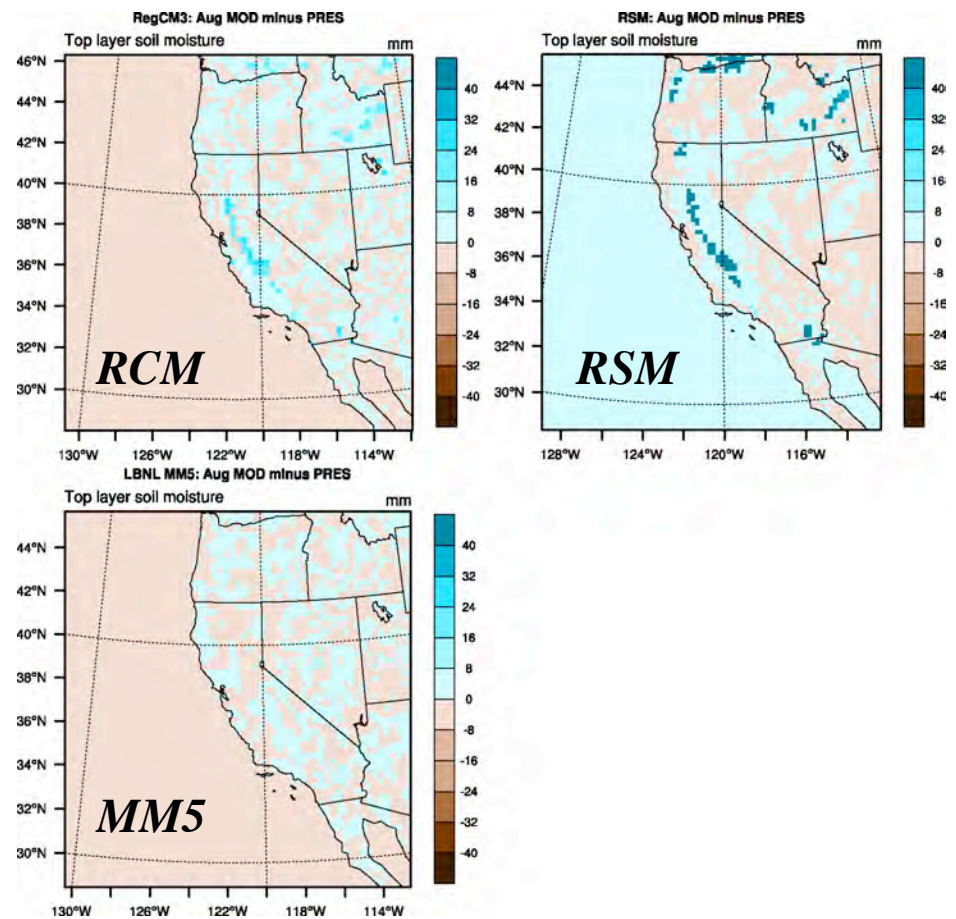
- Results are presented in the form of the Modern case minus the Pre-settlement case for each model
- Surface soil moisture, relative humidity, and surface temperature responses to the change in land cover for each are compared

Soil Moisture, Modern minus Pre-settlement (mm, top layer)

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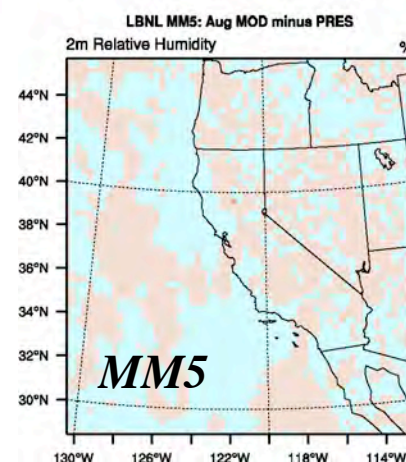
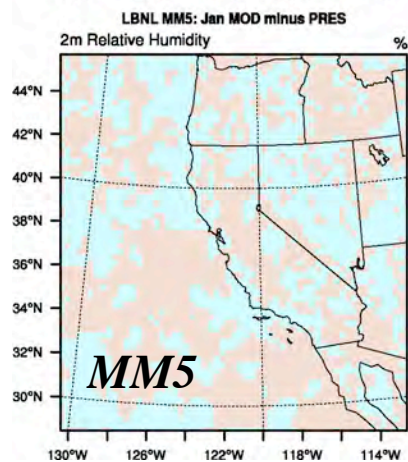
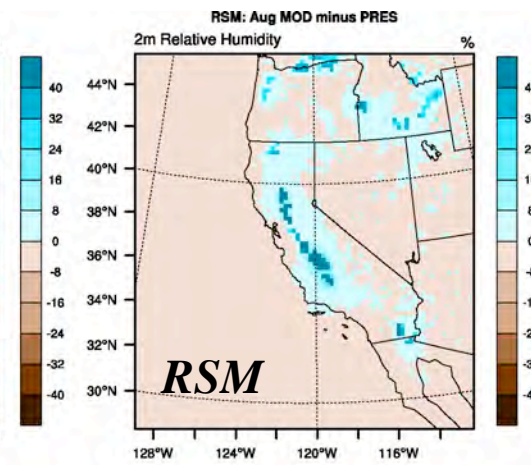
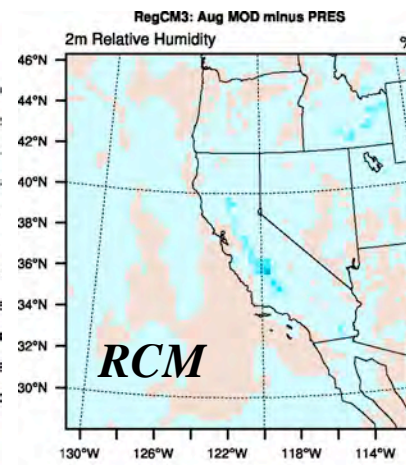
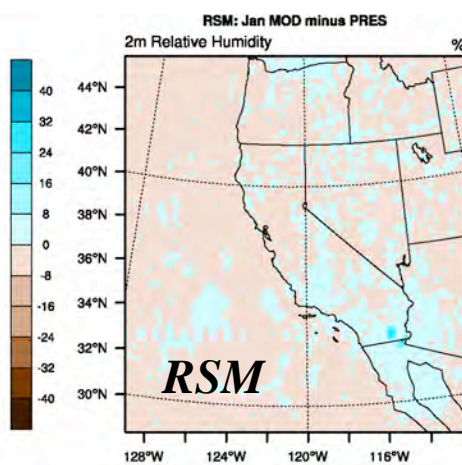
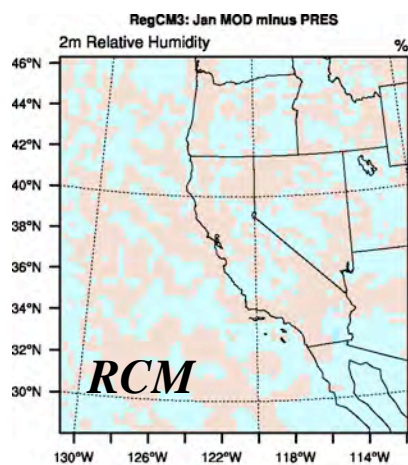
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Relative Humidity, Modern minus Pre-settlement (%)

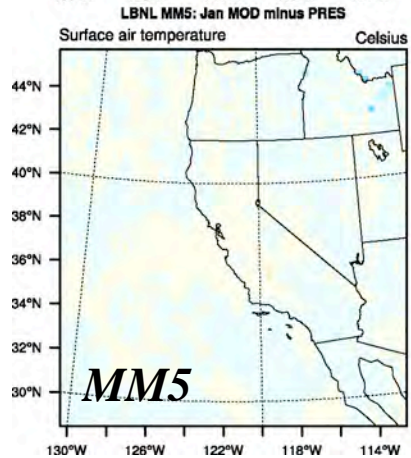
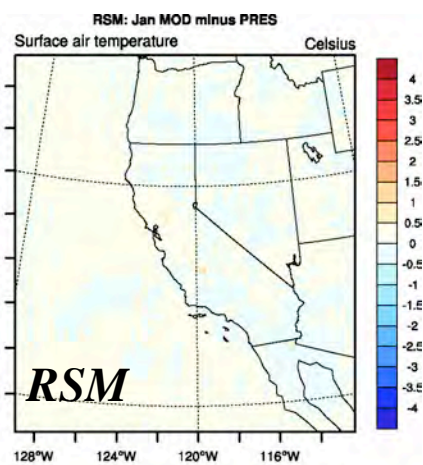
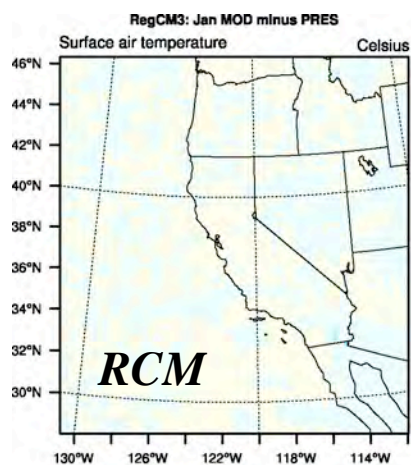
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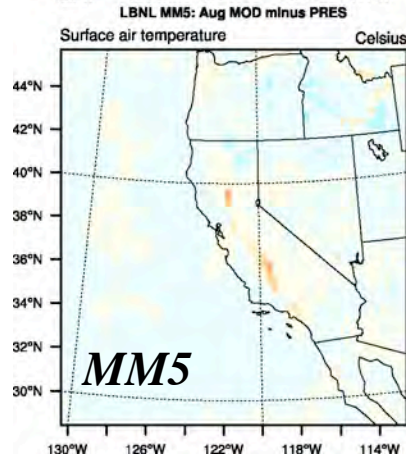
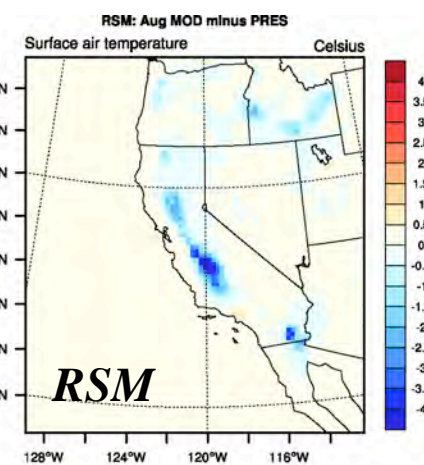
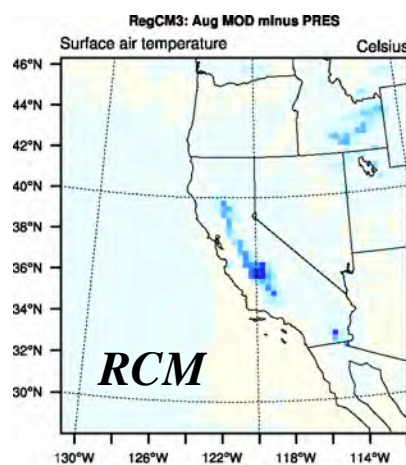


Surface Air Temperature (Modern minus Pre-settlement) (°C)

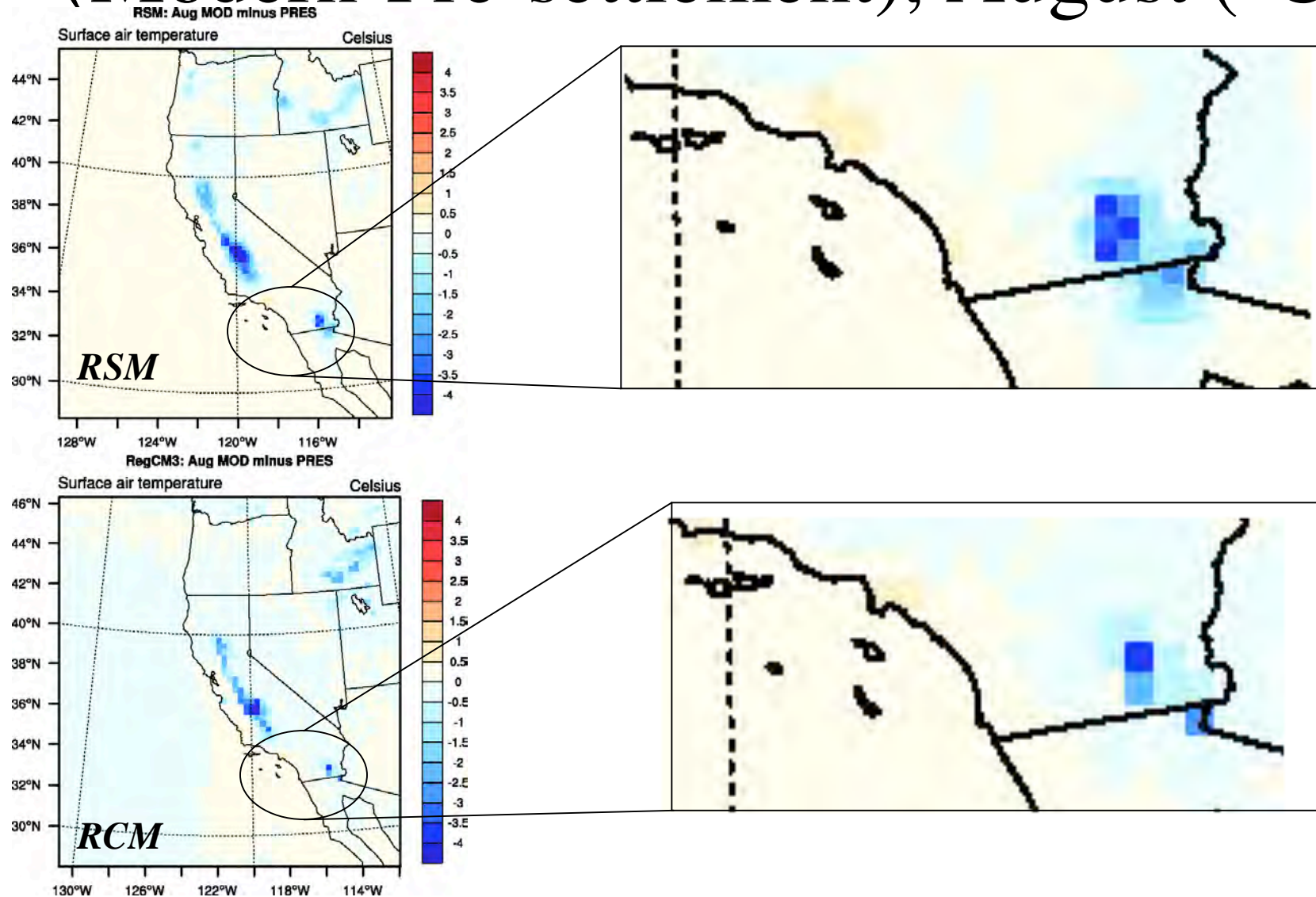
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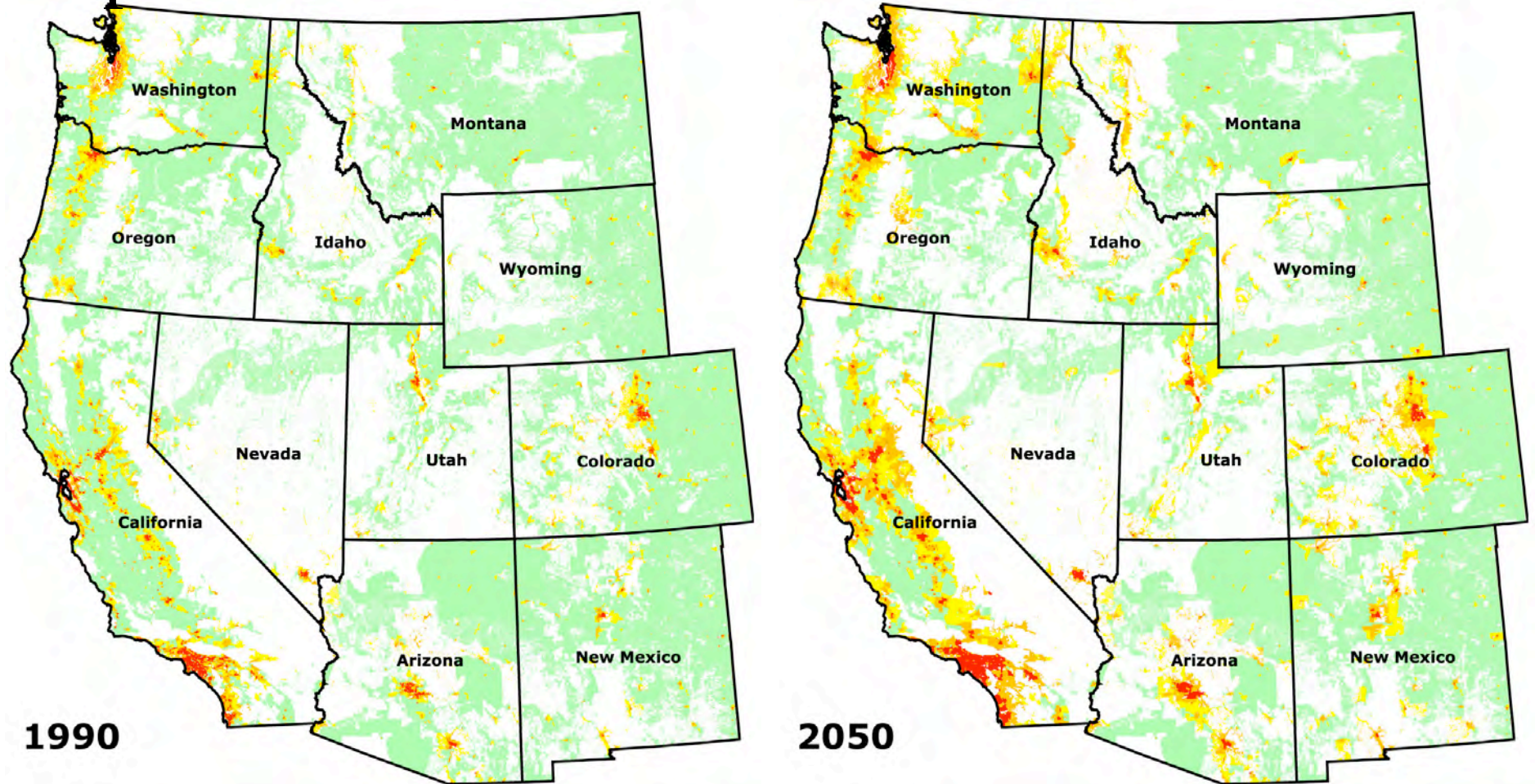
Surface Air Temperature Difference (Modern-Pre-settlement), August ($^{\circ}\text{C}$)



Summary of preliminary results

- Some models show modest temperature increases in areas of urban land cover
- Some models showed larger temperature decreases and increased relative humidity in areas of irrigated croplands (in the summer)
- The degree of cooling was proportional to the degree of soil moisture and associated evaporation, as determined by irrigated cropland parameterizations
- Importantly, the temperature change in response to the land cover change is the same order of magnitude (but opposite in sign) as some of the regional temperature changes that occur in response to increased greenhouse gas concentrations. And.....

As the areas of urban landscapes expand, the climate-land cover issue will become more important



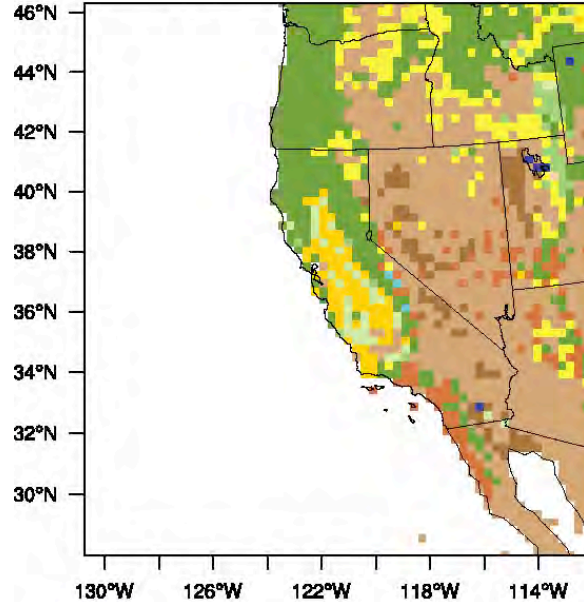
Theobald (2005) Ecology and Society

Acknowledgments

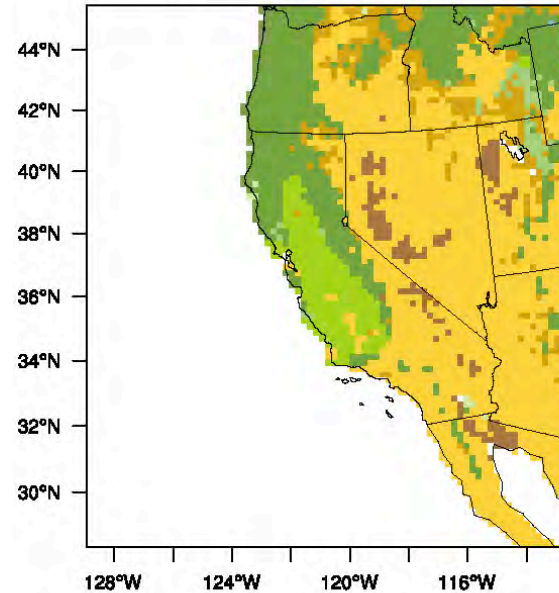
- We thank the California Energy Commission for financial support of this research
- Computing at UCSC was supported by grants from the National Science Foundation and the David and Lucile Packard Foundation

PRE-SETTLEMENT LAND COVER

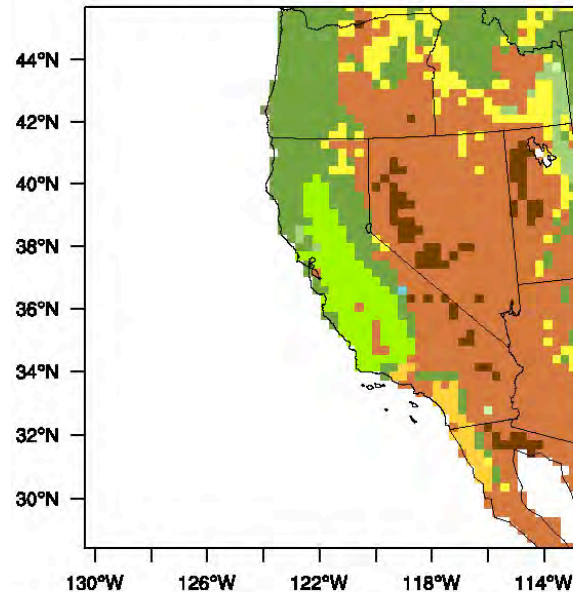
RegCM3 Presettlement Vegetation



RSM Presettlement Vegetation



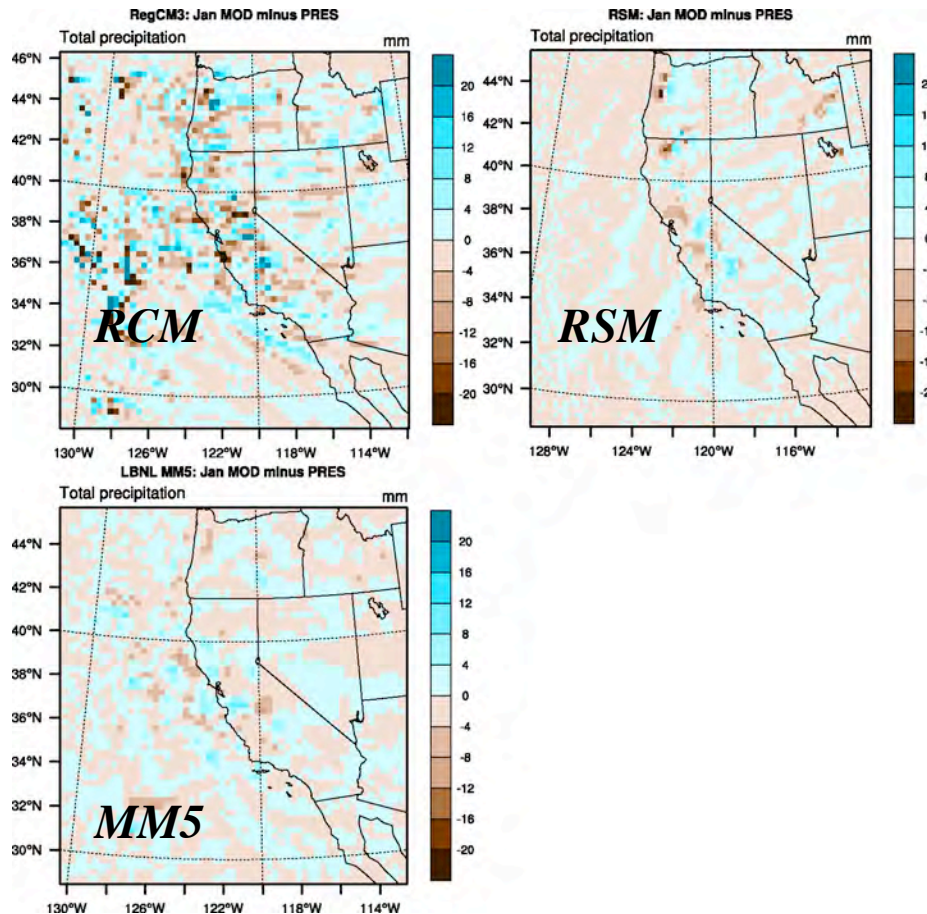
MM5-CLM3 Presettlement Vegetation



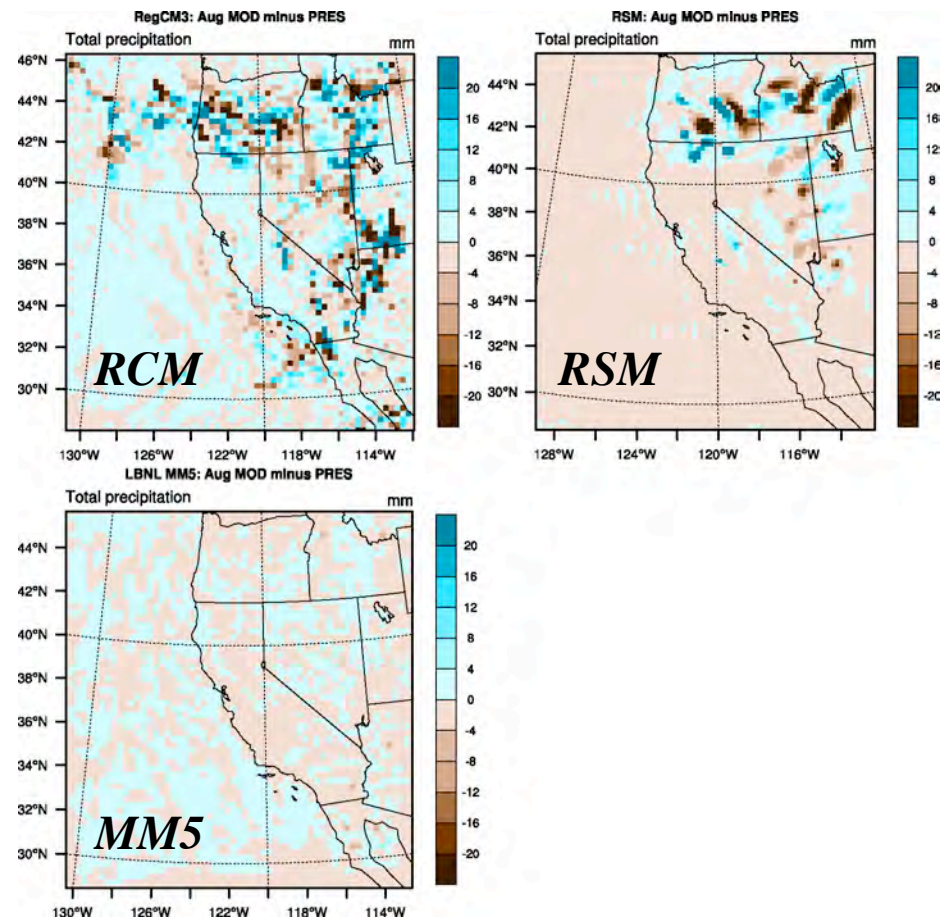
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- MM5 has more shrubland
- RegCM has more desert

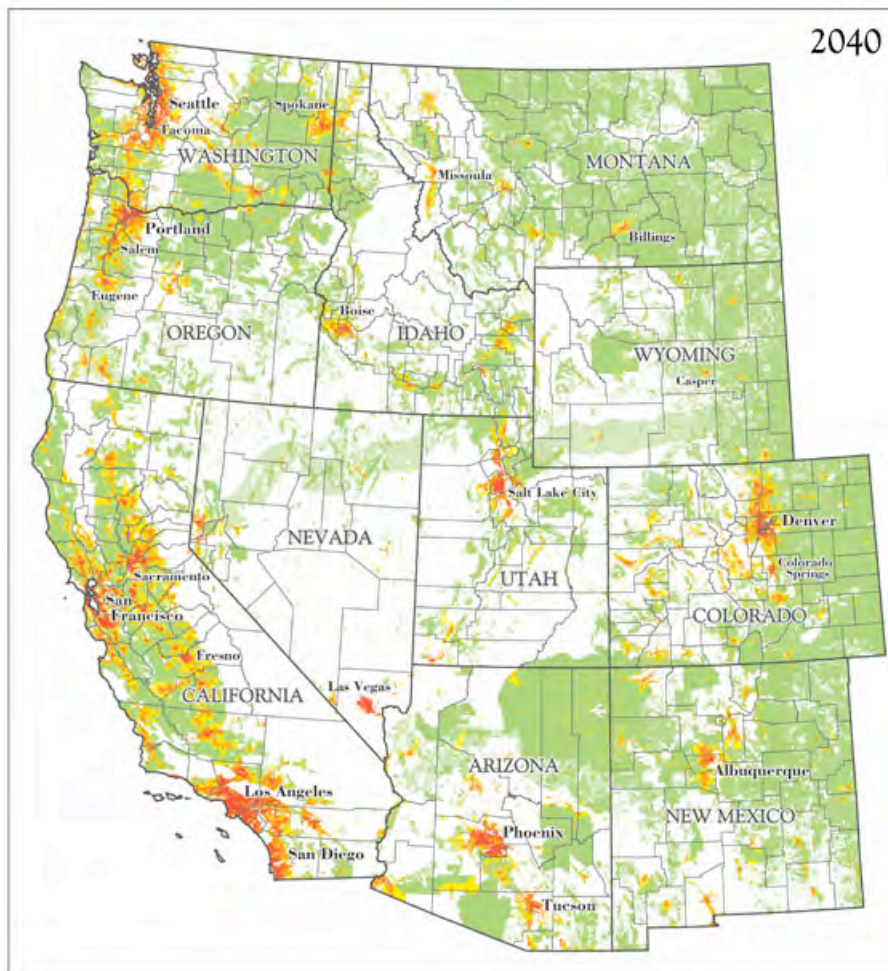
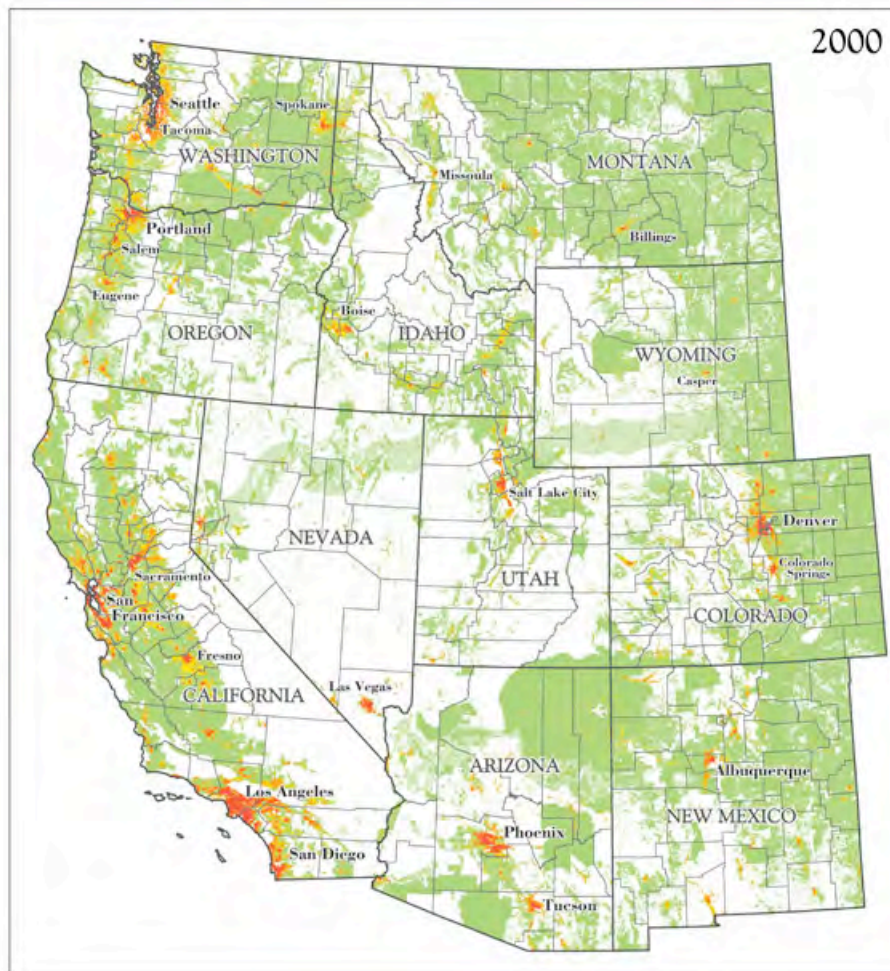
Precipitation, Modern minus Pre-settlement (mm)

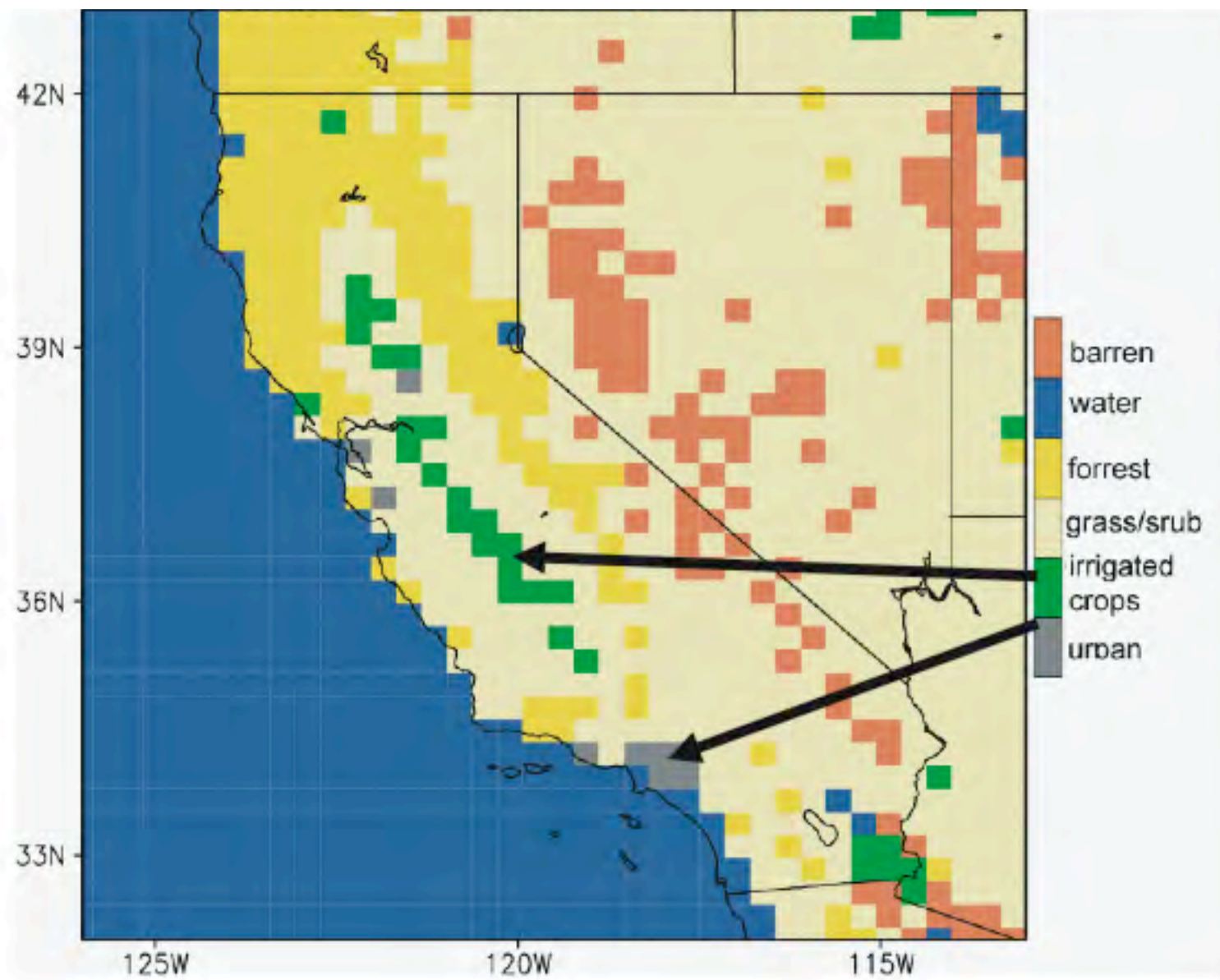
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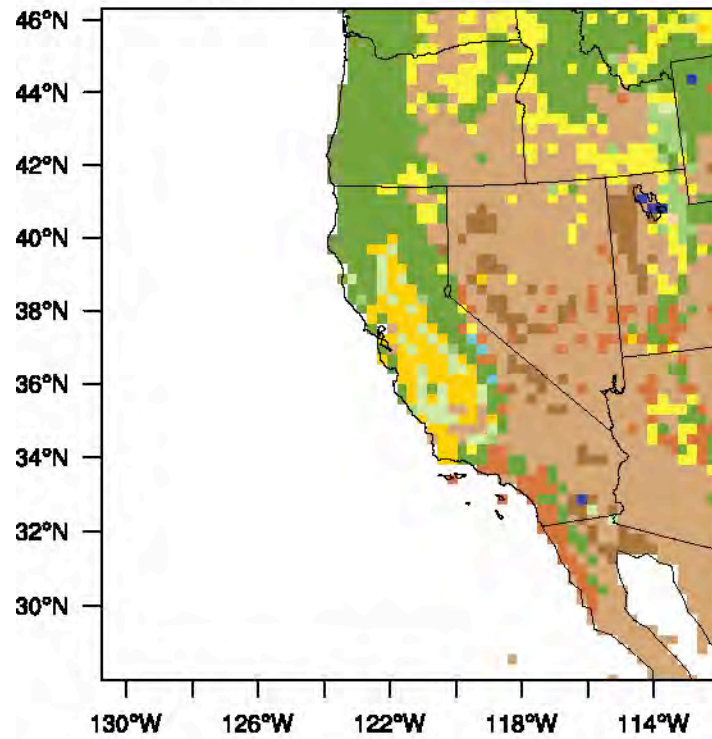
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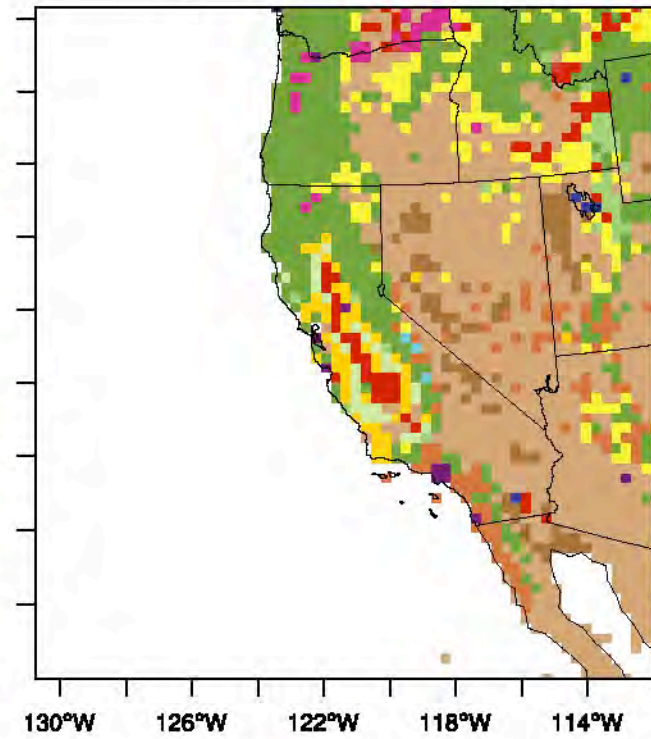




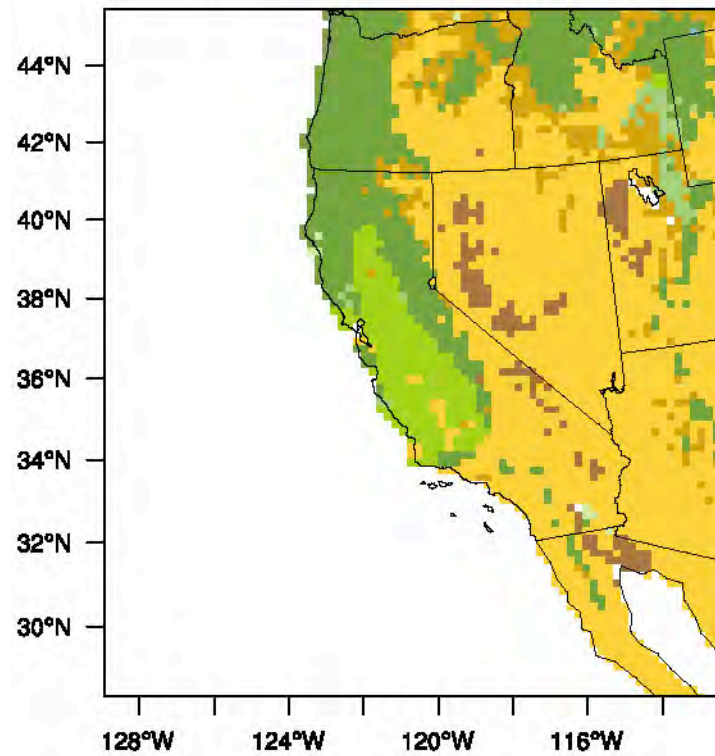
RegCM3 Presettlement Vegetation



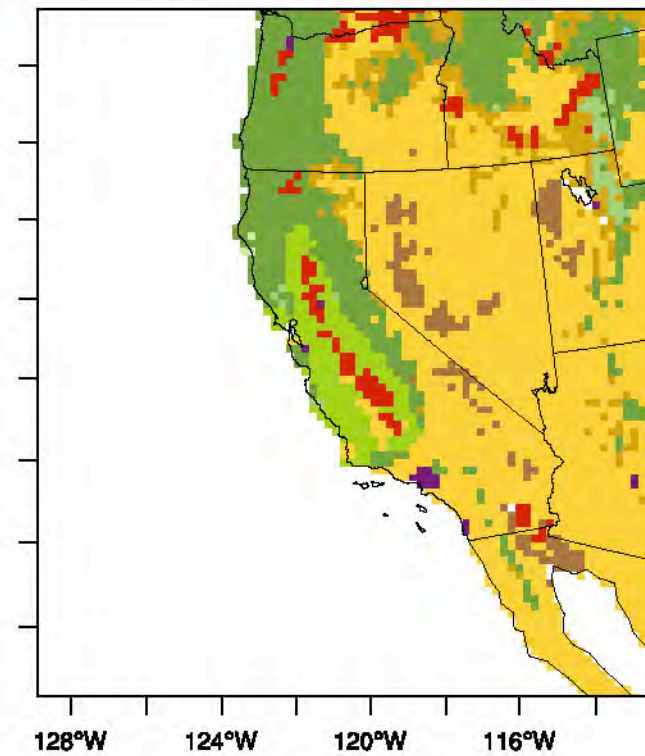
RegCM3 Modern Vegetation



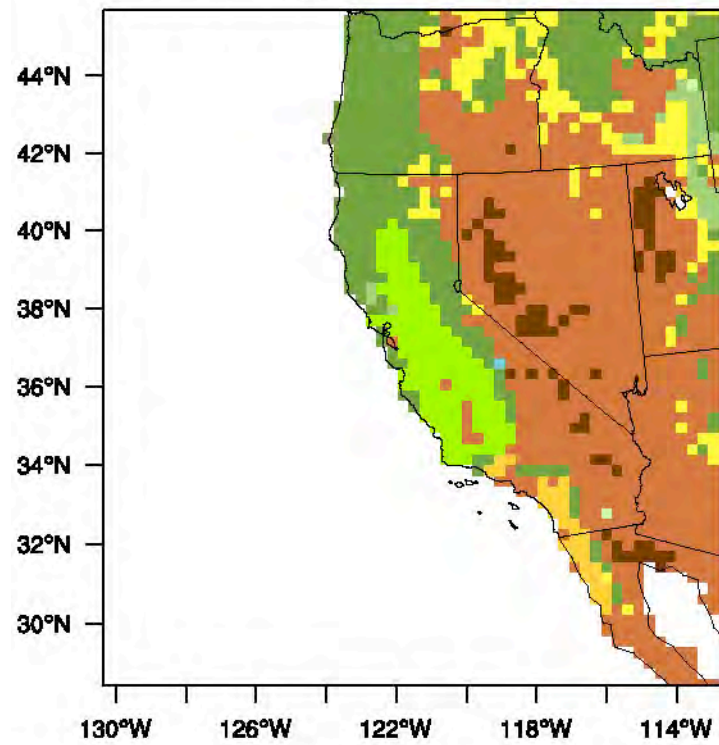
RSM Presettlement Vegetation



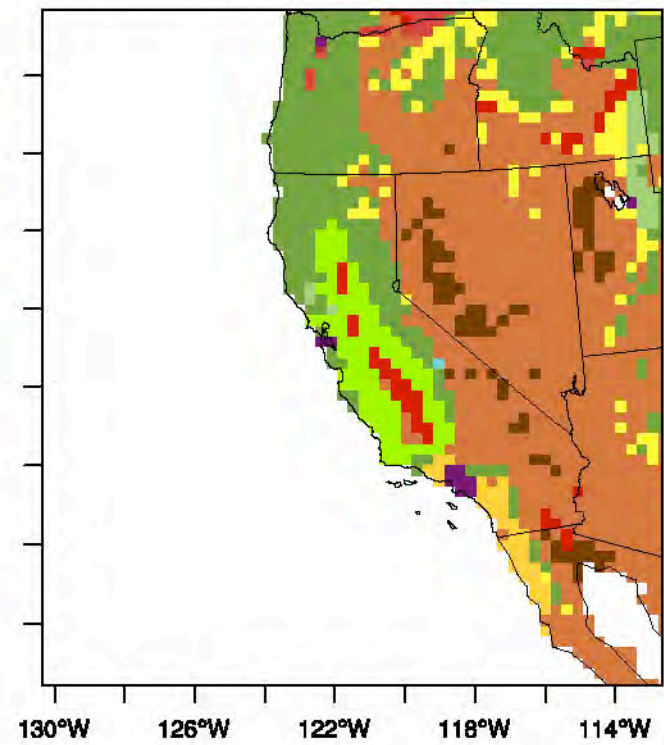
RSM Modern Vegetation



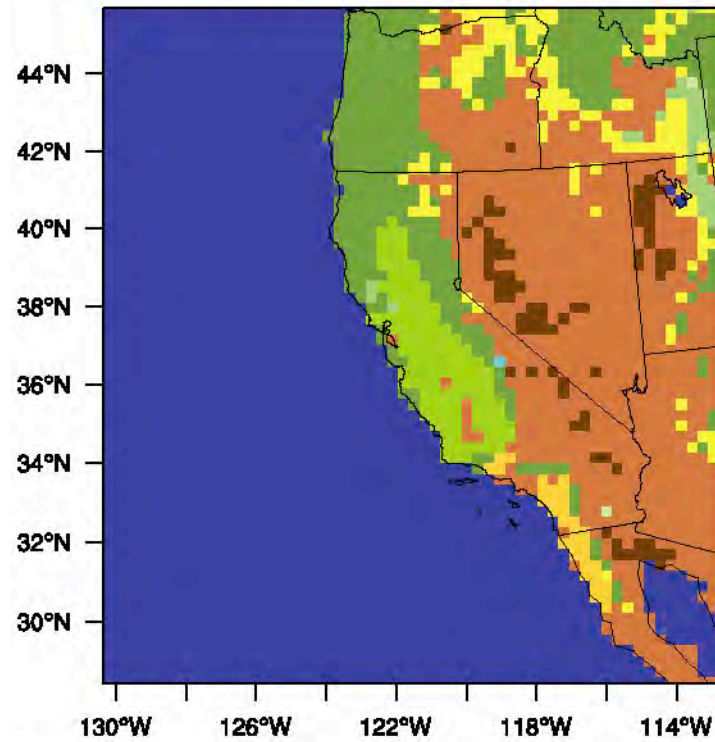
MM5-CLM3 Presettlement Vegetation



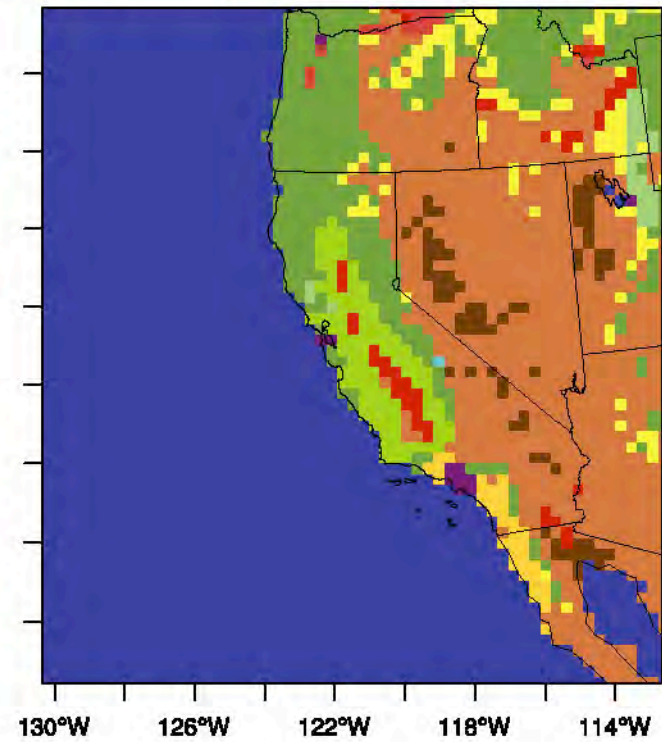
MM5-CLM3 Modern Vegetation



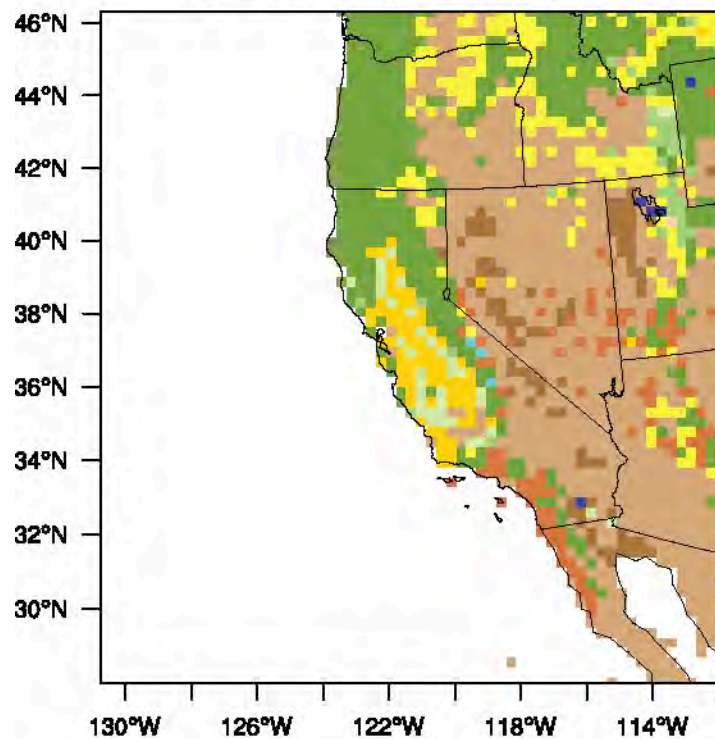
MM5-CLM3 Presettlement Vegetation



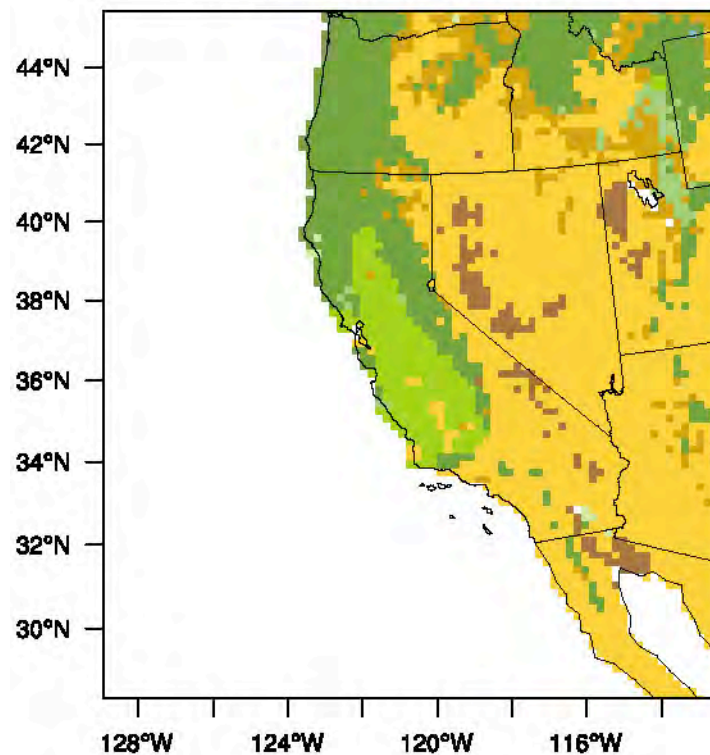
MM5-CLM3 Modern Vegetation



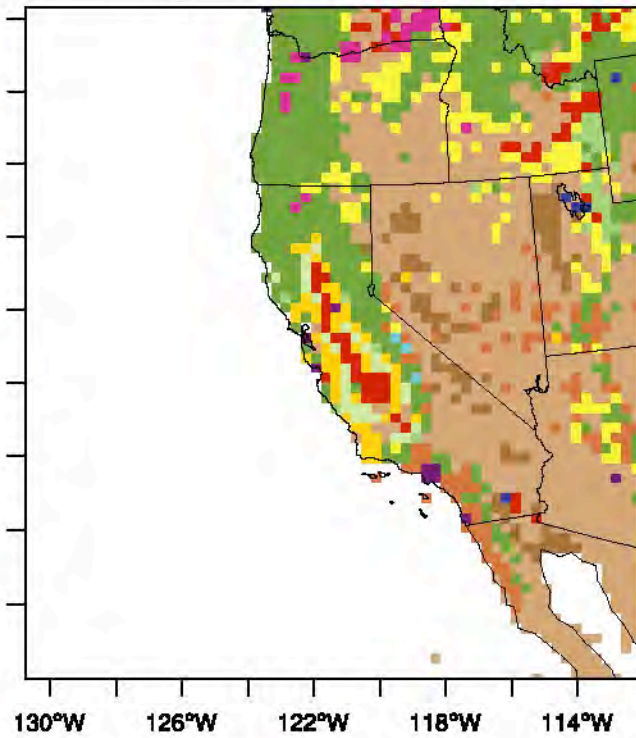
RegCM3 Presettlement Vegetation



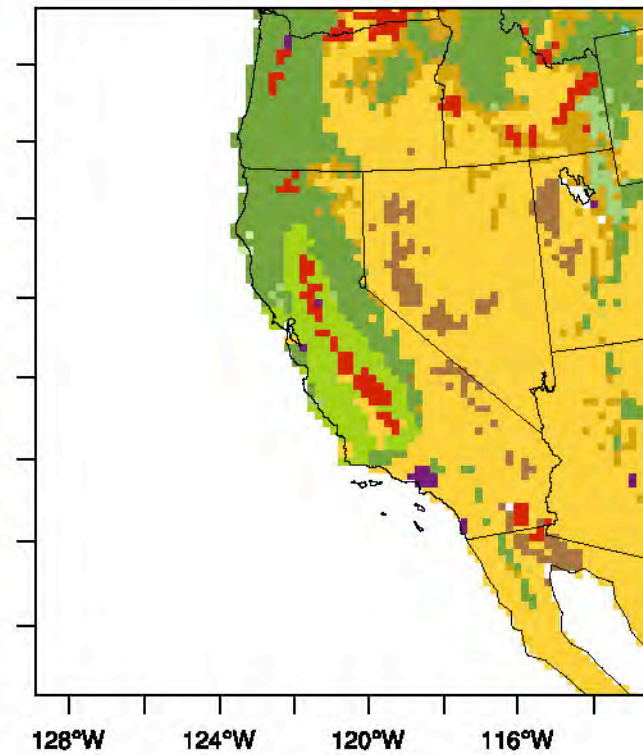
RSM Presettlement Vegetation



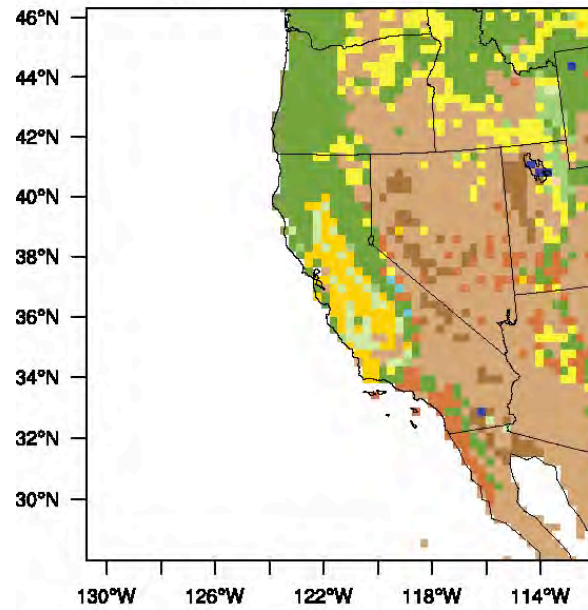
RegCM3 Modern Vegetation



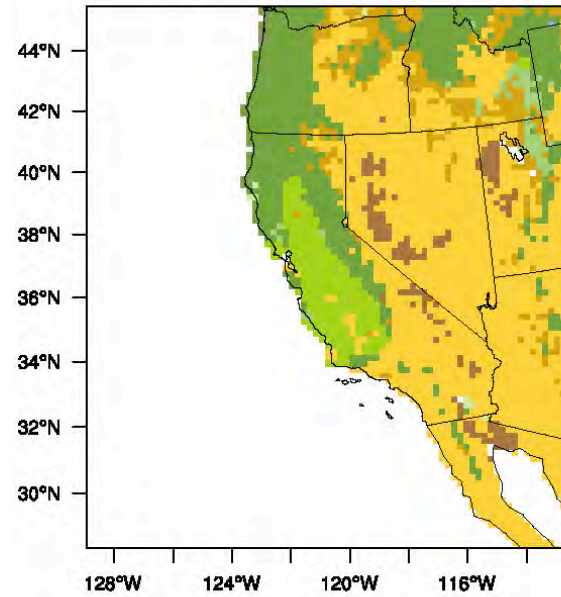
RSM Modern Vegetation



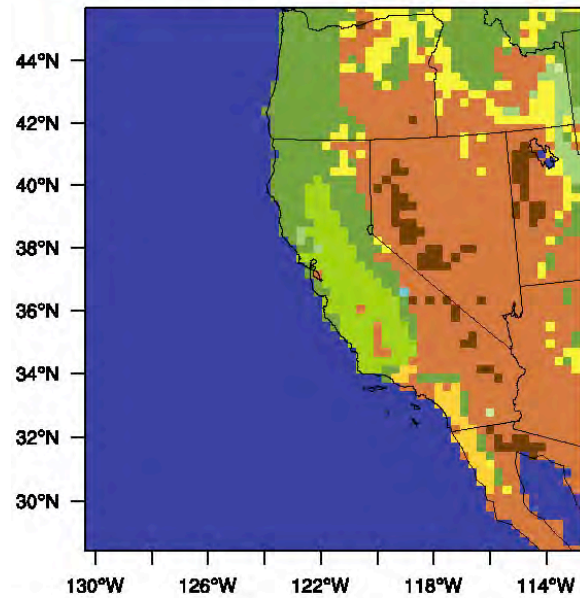
RegCM3 Presettlement Vegetation



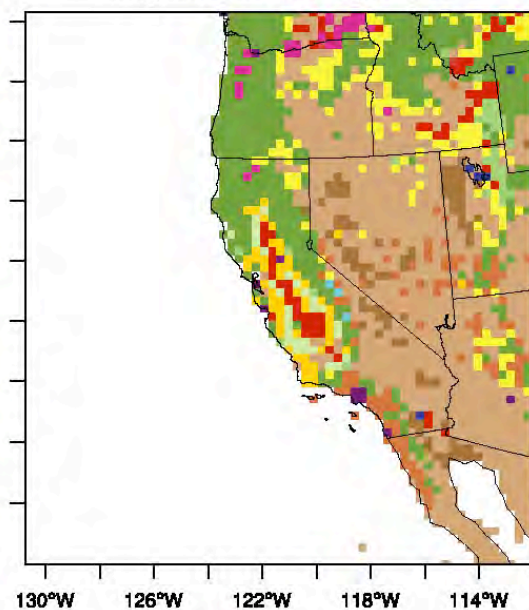
RSM Presettlement Vegetation



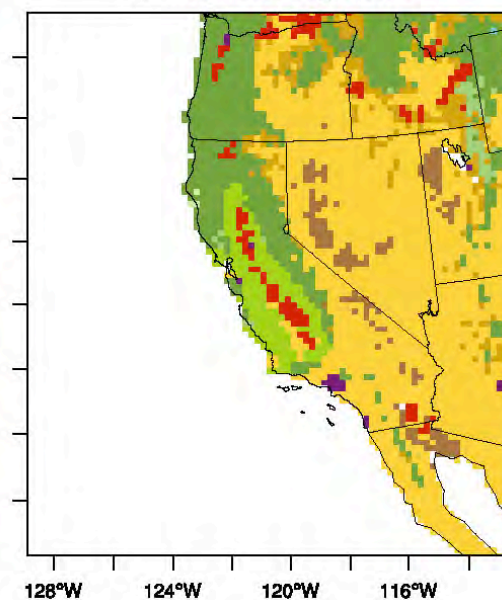
MM5-CLM3 Presettlement Vegetation



RegCM3 Modern Vegetation



RSM Modern Vegetation



MM5-CLM3 Modern Vegetation

